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VARIATIONS IN THE SECONDARY SEXUAL CHARACTERS OF THE FIDDLER CRAB

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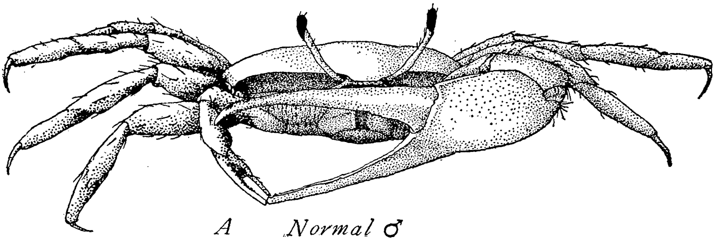
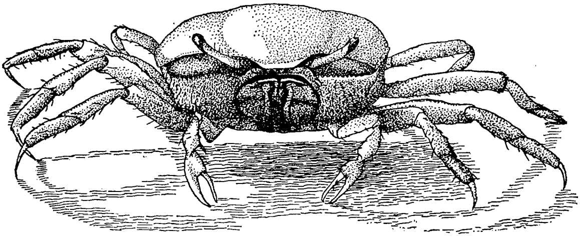
In species in which the ordinary individuals are sharply separated into males and females there are occasionally found abnormal individuals in which characteristics of one sex are mixed with those of the other sex. We are only at the beginning of the study of these cases, but enough work has been done to make it more than probable that there are several, or even many different kinds of situations that call for separate treatment. That this is generally becoming recognized is evident from the different names that have been used in describing these cases, such as intersexes, sex intergrades, hermaphrodites, gynanders, androgynes, pseudo-hermaphrodites, free martins, eunuchoids, protandrous hermaphrodites; monœcious, diœcious, triœcious plants, indifferent larvæ, neuter insects, etc. It seems to me not worth while at present to attempt to classify such material until we have learned more about it. Whether all or only some of the aberrant types of fiddler crabs here described should be called intersexes depends largely on the definition of what that term includes.

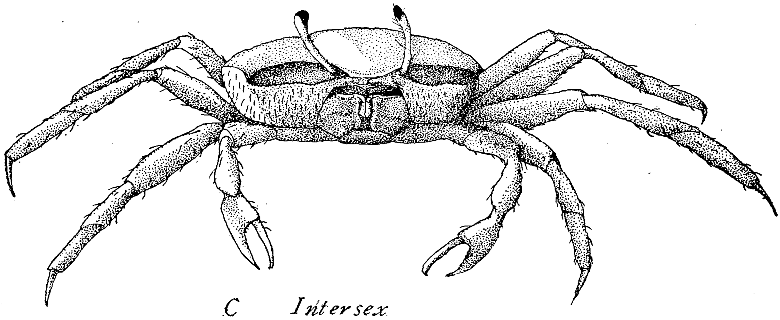
In the fiddler crabs the male (Fig. 1 *A*) and the female (Fig. 1 *B*) show not only the characteristic differences of other decapods, but one of the claws of the male is enormously enlarged. It may be either the right or the left one. If removed a new claw of the same kind regenerates from the stump although it may take more than one molt for the claw to become as large as the one removed. In the fiddler "compensatory regulation" does not take place as in some other decapods (Alpheus); that is, after removal of the large claw, the smaller one does not enlarge and substitute for it at the next molt.



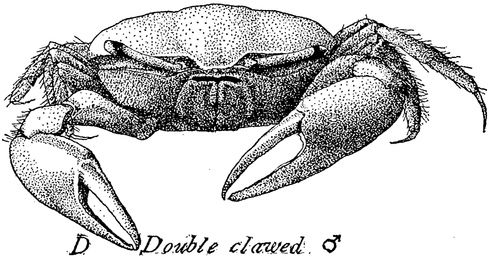
A Normal ♂



B Normal ♀



C Intersex



D Double clawed ♂

Fig 1

Moreover, and this is important, the characteristics of the new big claw are apparent as soon as the regenerated part begins to take shape, and even long before the molt.

The other most characteristic difference in the external parts between the male and the female is found in the abdomen. In the male, Fig. 2 *B,* it is narrow, in the female, Fig. 2 *A,* it is almost as broad as the ventral surface of the thorax against which it is plastered. If the abdomen of the male is lifted up, its anterior pair of abdominal appendages, modified into copulatory organs, can be seen (Fig. 2 *B′* and Fig. 3 *A*). In the female the abdominal appendages (Fig. 2 *A′* and Fig. 3 *B, B′*) are entirely different, and are used to carry the eggs. The external genital pores can also be seen when the abdomen is lifted up; those in the male on each side of the middle line are in the segment that carries the last (5th) pair

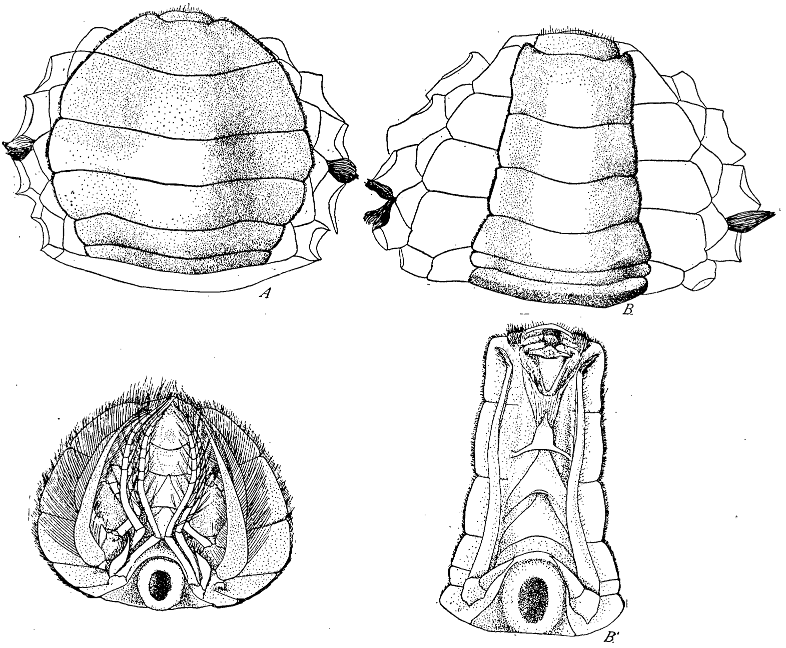


Fig 2

of legs, in the female they are further forward on the segment that carries the third pair of legs.

In the summer of 1917, at Woods Hole, Miss Grace Hays, while sorting out some fiddlers, found an individual that had a small first pair of legs like those in the female, but an abdomen like that in the male. Another collection of crabs was made and three other such individuals were found. In the summer of 1919 the collectors at Woods Hole brought to me more fiddlers, and from them more aberrant forms were obtained. It then seemed worth while to find out how often such individuals occur in this locality. Thanks to the interest shown by Mr. Wm. Procter and Mr. Alfred F. Huettner a large number of crabs were collected and carefully looked over.[1] As shown in the following table the number of aberrant individuals was found to be about .0077 per cent.

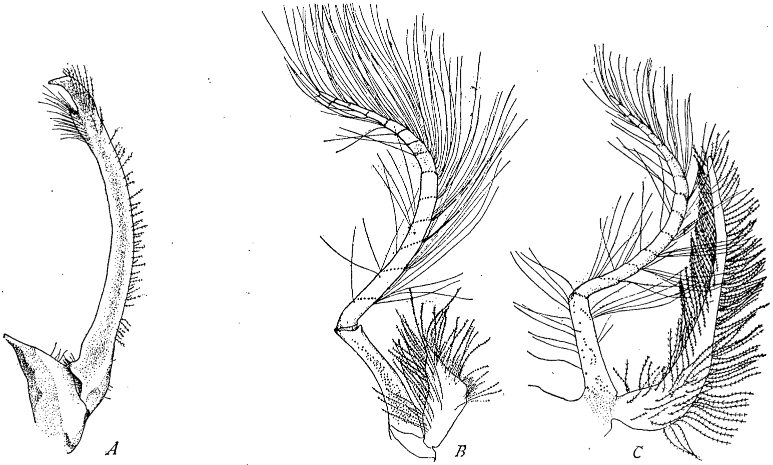


Fig 3

Normal	"Intersex"	
353	5	June 24, 1919
50	2	28
1,245	6	30
Total 1,648	13	

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[1] A few small intersexes were later obtained by Mr. Lionel Strong at Cold Spring Harbor, L. I. Mr. Procter later collected 2,068 crabs at South Wellfleet (July 4), but found no aberrant individuals amongst them.

A cursory examination showed that two types of individuals were present. The larger individuals had the abdomen of the male sex, but both claws were small and

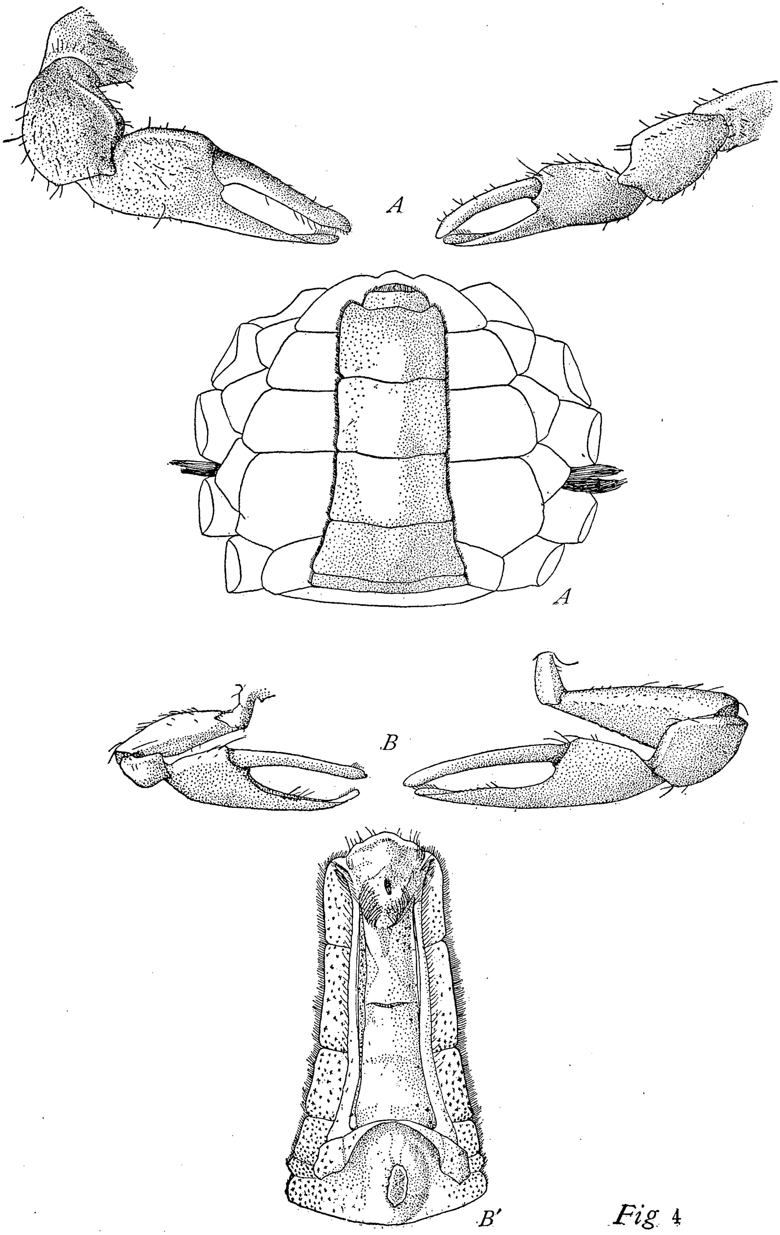

Fig 4

more like those of the female (Fig. 1 *C*). The other individuals had abdomens not quite so broad as those of typical females of the same size, Fig. 4 *B′*, yet their claws were generally small, like those of the female, and showed no indications of a variation towards the male type. Since the younger stages of some crabs, such as the blue crab, have a narrower abdomen than that of the adult female until the last molt, it seemed possible that these "intersexes" might at a later molt turn into typical females. They were kept therefore and well fed for two or three months during which time they molted once, Fig. 4 *B″*, or even twice. A comparison of the old skin showed that the condition of the abdomen and claws had not changed. It is evident that this condition can not be explained as transitory. Nor is it juvenile because normal individuals of the same size have the abdomen full width.

A more detailed examination of these two types may now be given. The most striking fact is that all of the full grown crabs belong to one category, and all of the smaller ones to another. The former of which there are six, have a strictly male abdomen regardless of the condition of their claws, and what is more significant the external genital pores are at the base of the last pair of legs, as in the normal male. As shown in Fig. 2 *A′* and *B′*, the abdomen is exactly like that of the male. On its inner side it contains the two long copulatory appendages of the male. The chelæ in three individuals are small, Fig. 4 *B*, and of the same size, resembling those of the female. In the other three one of the claws is somewhat larger, Fig. 4 *A*, than the other and shows unmistakably evidence of variation toward the male. The genital pores are, as stated, in the same position as in the normal male, and there are no indications of female pores further forward. In two cases at least, the crabs molted, but did not change their characters. In the second group, Figs. *A, B, C, D,* there are sixteen individuals. There is amongst these no obvious relation between the size of the crab and the relative width of the abdomen. Some of the smallest have the narrowest abdomen. There is some correlation between the character of the abdominal appendages, particularly the first pair and the width of the abdomen. As shown in Fig. 6 *A, B,* this appendage does not appear as much like that of the female of the same size, Fig. 6 *C,* as would be expected were it strictly female, yet it can not be said to be male-like, and the narrowness of the abdomen may be responsible for the difference.

The claws are like those of the female in all cases.

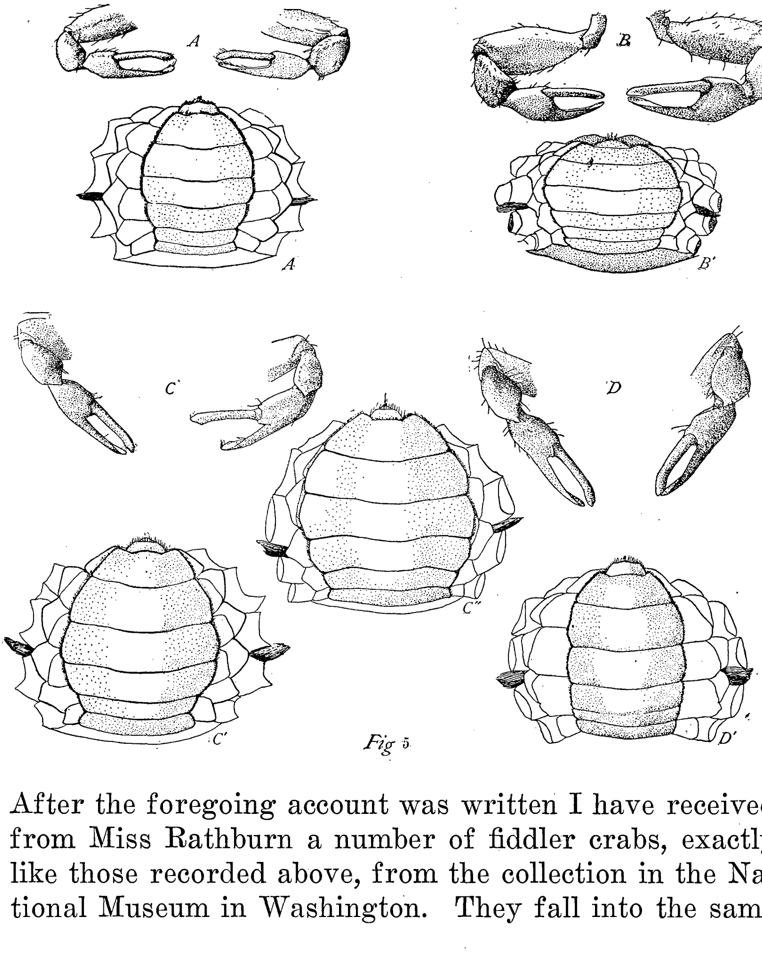

Fig 5

After the foregoing account was written I have received from Miss Rathburn a number of fiddler crabs, exactly like those recorded above, from the collection in the National Museum in Washington. They fall into the same two groups. One large male, labelled *Uca pugilator* (18286), has a pair of small female like claws. It comes from Northampton Co., Va. (1894). It belongs to a different species from those described above.

There are in this collection eight small female-like crabs with the abdomen narrower than that of the normal female of the same size. All of them have both small claws of the same size. In those with the narrowest abdomen, the abdominal appendages are straighter and less plumose than are those of the normal female of the same size. This condition might be described either as a juvenile, or as a less female-like condition, but not necessarily more male-like. In size and shape the abdomens of these crabs are like those of Fig. 5 *A, B, C, D.* In addition there is one small individual (17688) labelled "pugilator," with the abdomen about half the width of a normal female of the same size of the other species.

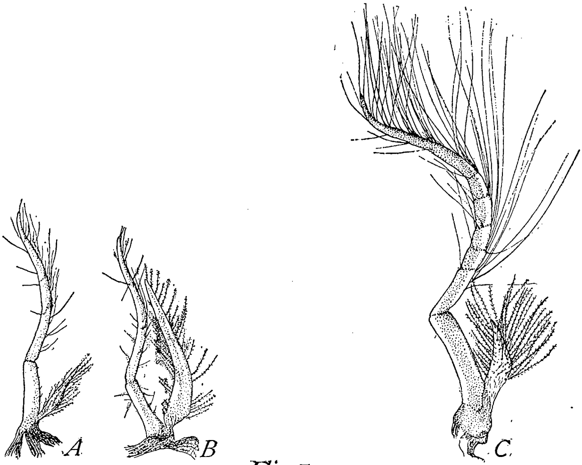

Fig 6.

There is also one further variation in the fiddler that is different from the preceding ones. It is shown in Fig. 1 *D.* Mr. G. M. Gray found this male fiddler (*Uca pugilatur*), and with his permission I am able to figure it here. It had two large claws, both like the claw of the normal male. I find that Professor S. I. Smith, of New Haven, recorded in 1869 a similar case of *Uca pugnax.*

At present we are entirely ignorant as to what causes determine in the normal male that only one side develops a big claw. The asymmetry of the fiddler appears to be analogous to that of the asymmetry of snails and of the one-sided operculum of certain annelids (*Hydroides*), etc. It is generally supposed that something comes in during the development of the male crab that turns the scale one way or the other; and once determined the relation persists during life in fiddler crabs, although in other decapods, as shown by Przibram, the initial difference may be reversed during regeneration if the large claw is removed and the small one left. Until we get further information concerning these matters it would be idle to speculate as to what has led in this male to two large claws.

It is interesting to note in the case of this male with two large claws that it differs from the ordinary males by doubling the kind of difference that distinguishes the normal male from the female. It can scarcely be said to be an inter-sex, for the difference is not in the direction of the opposite sex, but away from it. If some designation is called for, it might be said to be a super-male, or at least an over-clawed male.

DISCUSSION OF THE RESULTS

If we compare the results of parasitic castration of certain decapods with the conditions described here in the fiddler crab several resemblances and differences become apparent. First in none of the cases of parasitized crabs are the external genital openings affected. They furnish a certain clue to the original sex of the individual. Likewise in the large fiddlers the male external genital pores are present, and there are no female pores. The individuals have probably always been males. Whether the condition of their claws is due to some disease, or possibly to some internal parasite, or to a change in the genetic complex, can not be stated. It is even possible that it may be due to none of these, but to some "accident" in the development, *i. e.*, to some change in the embryology that determines the asymmetry of the normal male. The occurrence of the male with the two large claws may seem to favor the last interpretation; for here we find the reverse relation and it does not seem probable that such an over-clawed male could have arisen through parasitism, or through disease, although the argument for a genetic change can not be entirely set aside.

In regard to the other group containing the small aberrant forms the situation is somewhat different. All of these have started as females, as the location of the external genital pores clearly indicates. Yet some of them show also an apparent change towards maleness by the narrowing of the abdomen or possibly a retention of the juvenile condition. Here the change, if it be a change, is in the reverse direction from that shown by most of the intersexes described by Giard and by Geoffrey Smith, since starting as a female the change is towards maleness, while in the parasitized crabs it is the female that changes towards the male. The different degrees to which the change has taken place in different individuals may seem to indicate disease or parasitism. The absence of further change in the same direction in the next or following molts is not perhaps so favorable to this interpretation. But on the other hand the absence of adult crabs of this sort, or at least their infrequency may mean that these individuals do not reach maturity, and may therefore be diseased or infected[2] or that in the adult the full-sized abdomen is attained. These questions must be further investigated before a decision can be reached.

General and Hypothetical

It may seem, as stated above, that some of the changes seen in the fiddlers may be similar in kind to some of those brought about in other crabs by becoming parasitized. Giard has described several cases in crabs and other Decapods parasitized by other crustataceans (*Sacculina Portunion, Peltogaster,* etc.), in which changes take place in certain parts of the body that approach the condition found in the opposite sex. These changes involve most often the abdomen and its appendages, and in one species at least the claws. The most marked changes involved the male, producing in him alterations in the direction of the female. In one case *a female* is described as showing some effects of the parasite but if I am correct Giard interpreted this change as resulting from the retention of the juvenile condition. Giard contrasts the changes in the male crabs with those produced by castration in the vertebrates. He seems to imply at times that he supposed the effects are produced by the loss of the gonads. At other times, however, he speaks definitely of the changes as some sort of symbiotic relation between the host and the parasite—an idea similar in many respects to the later and more elaborated hypothesis of Geoffrey Smith. In fact, in summing up the evidence Giard recognizes two classes of cases; those due to the indirect action of the parasite by way of the testes, and those due to the direct, by action on the host. It was, of course, at that time natural to suppose that in both groups, vertebrates and crustaceans, castration acts in the same way, especially as the case of the vertebrates had been long in the literature, and zoologists had become familiar with this kind of effect. Moreover at the time other evidence was lacking to show in other groups that the gonads have no influence on the development of the secondary sexual characters. But the work of Oudemanns that was later fully confirmed and extended by Kopec and by Meisenheimer and by Kellog removed any prejudice that the situation in the vertebrates had brought about, so that at the time when Geoffrey Smith wrote the field was clear for an independent judgment. As stated Geoffrey Smith brought forward evidence that seemed to him to show that the changes in the secondary sexual characters in parasitized males were due to physiological processes set up by the parasite in the host. He even went so far as to compare directly and in detail the substances called forth in the host by the action of the parasite. Without discussing these questions here (since I have recently discussed them in my paper on "The Genetic and Operative Evidence Relating to Secondary Sexual Characters," Carnegie Publication No. 285, 1919) it is evident that crucial experiments must be made on the crabs themselves before a conclusive case can be made out. This is by no means a simple matter as I have found. During the last three summers at Woods Hole I have tried to carry out experiments on crabs to test some of these questions. All attempts to remove the gonads in fiddler crabs have failed, because of the delicacy and distribution of the organs, and the fatalities that result when the carapace is lifted up. Attempts such as Stamati made in 1880 to destroy or injure the gonads by injecting substances through the genital pores have also failed, because of the delicacy of the tubes and the distance of the gonad, in the male, from the external genital opening.

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[2] Geoffrey Smith has described changes in the crab *Inarchus* brought about by inflection of a gregarine. The abdomen and claws of the male were changed in much the same way as when this crab is parasitized by a barnacle. Giard has described an hermaphrodite amphiurian, parasitized by Orthenectidæ, that cause the ovary to degenerate while the testes continue to function.

Some important observations made by Kornhauser (1919) on the effects of parasitism of the tree-hopper, *Thelia bimaculata,* by the hymenopteron, *Amphelopus thelia,* have a bearing on the preceding discussion. The egg of the parasite is deposited within the body of the nymph of *Thelia* from the first to the fifth instar. The egg or eggs give rise to a number of "polyembryonic" larvæ, that ultimately destroy the host. Infected males show in the adult stages many of the characteristics of the female, the degree to which the change takes place being mainly dependent on the stage at which parasitism occurred. The change involves the pigmentation, the size, certain abdominal spines, the shape of the abdominal sclerites that approach or even reach the condition found in the female. The genital appendages do not change into those of the female, but remain small and lose their specific characteristics.

Parasitized females do not assume any of the features peculiar to the males.

The gonads in both sexes usually degenerate, and an accumulation of fat takes place in the abdomen of the host. Two exceptional cases have an important bearing on the cause of the changes resulting from the parasitism. One male was found that had been parasitized, and although it had been considerably changed towards the female in its somatic characters it "contained full-sized normal testes with many spermatozoa." Evidently then the changes caused by the parasite are not due directly to the destruction of the gonads as shown by this individual in which the gonads had escaped. This accords with the results of artificial castration in other insects.

The other exceptional case (fourth instar) had a "perfect female soma" but contained testes. The individual had started as a female. There was evidence of this, though it is not conclusive, in the chromosome counts of the somatic cells. It must be supposed that at an early stage something changed the cells of the germ-track, so that its cells developed into testes. This conclusion is borne out by a count of the chromosomes of the testes that show 21 cells in the spermatogonia, one of them being the large X chromosome characteristic of the male. An early "elimination" (loss) of an X chromosome from the mother cell of the germ-track, such as occurs in *Drosophila,* would seem to be the simplest explanation of this case, as suggested by Kornhauser.

The conclusion from the evidence is quite convincing, namely, that the several characters peculiar to the male are changed into those peculiar to the female as a result of the direct action of the parasite, and not through any influence by way of the gonad.

Feeding Fiddler Crabs on the Genital Glands of the Opposite Sex

During the summer of 1918 I carried out some feeding experiments. The occurrence of hormones in the reproductive "glands" in other animals suggested the possibility that the secondary sexual characters of fiddler crabs might be affected if the crabs were fed on the organs of the opposite sex during the period of regeneration of the large claw. Male fiddlers whose large claw had been previously removed, were fed exclusively, and at intervals of two or three days, on the ovaries of female spider crabs. The fiddlers were kept until they moulted about a month or two later. The new claw showed all the characteristic features of the normal large claw. Its regeneration had not been affected by the character of the food.

Female fiddlers, one of whose claws had been previously removed, were fed on the testes and the ducts leading from them of the male spider crab. Other females were fed on what appears to be a large gland in the posterior part of the abdomen of the male. No effect on the regenerating claws were observed.

These negative results do not show that there is no hormone in the gonads of the crab that affects the secondary sexual characters, for even if there were such, it might not be able to produce its effect through the digestive tract. Only positive results of this kind would be important but none were obtained. As the results were entirely negative they need not be further described.

A more promising test consisted in boring a hole in the carapace of the male fiddler and inserting pieces of the ovary of the female fiddler. Conversely for the female. There are certain implications in Geoffrey Smith's views that seem to imply that male tissue can not survive and grow in an individual with female metabolism, and perhaps conversely for the male. The small grafted pieces often become lost, and it is difficult to determine later by means of sections how far the tissues degenerate and how far they become implanted and grow. I have not had the time to carry out a detailed study of the sections, but they seem worthy of further examination. No effect on the claws were produced.

A PIECE OF AN OVARY PRESENT IN A MALE CRAB

A normal male fiddler was opened to obtain pieces of its testis. In the region where the left testis is supposed to end there was found a small piece of ovary with its purple eggs. These were sectioned and found to be normal eggs. This observation is significant in so far as it shows that ovarian tissue can grow and differentiate in a purely male environment. The explanation of this occurrence is not at hand. One is tempted to refer to it an abnormal cell division in the testis of such a sort that the chromosome combination (if such exists) to produce eggs was formed, but in the complete absence of information concerning the chromosome composition of the male and female crustacea, such an attempt would appear premature.

INTERSEXES AND GYNANDROMORPHS IN CRUSTACEA

If it does not seem probable that the aberrant types in the fiddlers, that have been described above, can be safely referred to parasitism, it may not be without interest to point out that there are many other queer cases of sex mixtures in the crustacea, that do not appear in any way connected with environmental changes—or at least not directly.

Many cases of intersexes have been described in the Cladocerans, in the genera *Daphnia, Alona, Leptodora, Simocephalus,* under the name of androgynes, gynandromorphs, intersexes, etc. (Kurz, 1873. Grochowki, 1896. Woltereck, 1908. Kutner, 1908. Ashworth, 1913. Agar, Banta, 1918. De la Vaulx, 1915 and 1918). The antennæ more often show modifications characteristic of both sexes, but other organs are frequently involved, including even the gonads. There are no indications of parasites in any of these cases, where owing to the transparency of the body they would be easily detected if present.

Kutner has recorded the sporadic occurrence of intermediate forms through 12 generations of *Daphnia pulex* —in a line having a relatively high percentage of these forms. No recognized form of inheritance can be detected in these parthenogenetic lines. If, as generally supposed, there is no elimination of chromosomes in the parthenogenetic egg of Daphnians, the expectation would be that all offspring of an intermediate would be like the mother, whether the "character" were recessive or dominant. It would seem then that if certain lines of parthenogenetic Daphnians do produce more intermediate types than occur in the general population, we must look either to irregularity in the chromosome behavior or to environmental influence. The latter seems excluded by Banta's results to be mentioned later. The former can only be hypothetical until such differences are found. Nevertheless the discovery of such cases in other groups (*Drosophila, Œnothera*) makes the suggestion at least not so speculative as might have appeared several years ago.

The most important results are those recorded by Banta, not only because he has obtained a much higher percentage of intergrades, but because these appeared in a pedigreed strain, and the appearance of the intergrades has been carefully followed through later generations. In the 131st generation of one of the strains there appeared males, females and *sex intergrades*. The last group composed of "males with one or more female secondary sex characters, females with one to several male characters and some hermaphrodites with various combinations of male and female secondary sex characters." Highly male-like females produce only a few young or are sterile. "A female intergrade with as many as six strong male secondary characters rarely produces young." Males that have one or more female characters have nearly always incompletely formed testes. The strain was kept up by breeding from female intergrades that continued to produce females, males, and sex intergrades for 16 generations with no apparent change in the ratio of the various sex forms." The picture here presented can not but suggest some sort of disintegration or variation in the chromosome mechanism. At present we do not know how a parthenogenetic female sometimes produces female (parthenogenetic) broods, at other times male broods or sexual eggs. That such changes may be brought on by environmental changes seems not improbable from the large amount of data already collected. The results in these respects are so similar to those in rotifers where the situation is now under control (Whitney) that one can scarcely resist the conviction that in both cases the environment acts in producing the changes. But while we have no explicit evidence, as yet, even in *Hydatina,* that the environment acts only by bringing about changes in the chromosome mechanism, there is at least nothing known opposed to such a view, and some general arguments that incline one to anticipate such a discovery. Until these matters are set straight not much is to be gained by speculating as to how the sex intergrades of *Simocephalus* and other *Daphnia* arise. But if it should be found that the normal cycle is caused by alterations in the chromosome cycle, as has been shown in fact for Phylloxerans and Aphids, then I think we may have to look to some aberrations in the same mechanism to explain these anomalous cases. Indeed the kind of inheritance described by Banta appears to be one that might be expected from such a situation.

In the genus *Cyclops,* Mrázek (1914) has described "androgynes" that have modifications in the antennæ, and Bremer (1914) has recorded two cases of "pseudohermaphrodites" in *Diaptomus.*

In sharp contrast to these kinds of intersexes in the lower crustaceans stand out the bilateral gynandromorphs that have been found in two genera of lobsters. Nichols in 1734 described a lobster whose right side was female and whose left side was male. Dissection showed an ovary in the female side and a testis on the left. A similar case was described for *Palinurus* in 1902 (Burger), but no dissection was made.

In the *Canadian Naturalist* for May, 1919 (Vol. XXXIII, No. 2), there is a description of another "hermaphrodite" lobster. In reply to a letter of inquiry that I sent to Mr. A. P. Wright, he states that the lobster was sent to him by Mr. Halkett and that the animal is male on the left side and female on the right side. There is an ovary on one side and a testis on the other. These three cases appear to differ from the preceding cases and suggest a direct comparison with the bilateral gynandromorphs of insects. It is quite possible that they owe their origin to some similar chromosome "elimination" in the course of development, but it should not be forgotten that sex-chromosomes have not been reported in the lobster, although the cytology of the spermatozoa has been often examined.

Another decapod, *Gebia major,* has been shown by Ishikawa to be hermaphroditic. The anterior end of the testes produces sperm and the posterior eggs. A pair of ducts leads from each part to the exterior. Such individuals appear to function only as males. Spitschakoff found in a crab, *Lysmata seticaudata,* that both ovaries and testes are present with their ducts and external genital pores on the third and fifth pairs of legs. The anterior end of the gonad functions as ovary and the posterior as testes, which is the reverse relation from that of *Gebia.*

In crayfish belonging to the genus *Parastacus,* von Martens, 1870, von Ihring, Faxon, 1898, and Lonnberg, 1898, have described genital pores on the third and fifth pairs of appendages. Lonnberg has dissected some of these individuals. He finds testes in some of them, ovaries in others, but in both cases there are two pairs of ducts lead to the genital pores on the third and fifth pairs of legs. Here there is no true hermaphroditism, but on the contrary separate sexes. Nevertheless the ducts characteristic of the males and females in other species with separate sexes are both present in all individuals of *Parastacus.*

Selbie points out that Wollebaek (1909) showed that *Calocaris macandreæ* is normally hermaphroditic, each individual having testes and ovaries. The first pair of abdominal appendages has its tip expanded in all individuals as in male decapods.

In some of the amphipod crustaceans, the occurrence of ova in young males seems to be a normal occurrence recalling the conditions in frogs. Nebeski (1880) stated that the anterior end of the testis of *Orchestia gammarillus* contained ova. DellaValle, 1893, never found many eggs in *Orchestia deshayesii,* and none at all in sexually mature males. Geoffrey Smith made some further observations and attempted to explain the results on his anabolism-metabolism view. Ch. Boulenger studied the two forms mentioned above. Out of 137 males of *O. gammarellus,* 135 had no ova and 2 had a few ova anteriorly. Of small individuals, on the other hand, nearly all contained ova in the testis (198 with and 19 without ova). "These results are therefore much at variance with those obtained by Smith and I am at a loss to explain how he arrived at his conclusions."

Intersexes and Hybridization

In recent years several cases in which intersexes appeared in considerable numbers have been shown to be due to intercrossing. This raises the question whether some of the aberrant individuals here described may not have been due to crosses between the two species of fiddlers *Uca pugnax* and *Uca pugilator.* It is true that the latter is found most often in sandy stretches and the latter on muddy flats, yet the two are not infrequently found together or in nearby localities. The larger intersexes appear to be unmistakably *Uca pugnax*; the smaller are more difficult to identify. Miss Rathburn has examined both the large and the small individuals here de-

[3] Ewing ('85) has described a blue crab in which the abdomen is intermediate in width between that of the adult male and female. He thinks that the individual is hermaphrodite, but as shown by Churchill, the peculiarity described is the normal condition of the juvenile female before the last molt.

scribed and reports that they all belong to the species *Uca pugnax,* and show no signs of being hybrids.

The most interesting cases of intersexes are those produced by Goldschmidt in crosses between different races of the gypsy moth. He describes some crosses that give individuals showing only a slight tendency towards the opposite sex; other crosses go further until finally the male may be completely transformed into females, the change even including the appearance of eggs in the gonads. Conversely females may be changed towards maleness in various degrees depending on which varieties are crossed. His interpretation in general is that the two kinds of sex genes have different values in different races, so that the hybrids are in these respects betwixt and between so far as the influence of the sex genes is concerned. As I have recently discussed at some length Goldschmidt's view (see Carnegie publication, No. 278, 1919, and No. 285, 1919), I need not go over the ground again.

Harrison has more recently described intersexes in the offspring of different species of moths belonging to the family of Bistonidæ.

In this connection it is interesting to note that some of the phenomena seen in these moth crosses appear when crosses are made between two species of *Drosophila,* namely, *D. melanogaster* and *D. simulans.* Made one way the cross gives only females as A. M. Brown discovered, and as Sturtevant has verified. Reciprocally only males are produced, as I have found, with a few females hatching late in the series. In both cases, however, the hybrid males and females from the two crosses, although sterile, are strictly one or the other sex both in their gonads and in their secondary sexual characters, but as stated the gonads are rudimentary. Sturtevant's recent discovery of real intersexes in a race of *Drosophila simulans* has an important bearing on the interpretation of intersexes. He finds in a certain line that individuals appear that show characters both of the male and of the female, including especially the genitalia. They have rudimentary gonads. Breeding from normal heterozygous sisters and brothers he has shown that there is present a recessive gene that gives the intersexes when present in double dose in females. This gene is in an autosome. The results are shown, therefore, not to be due to a change in the gene or genes for sex, but to a gene whose effects are superimposed on the influence of the sex genes. It is evident that such a possibility must be reckoned with in interpreting other cases.

Intersexes have been found in human lice, *Pediculus,* by Keblin and Nuttall. The evidence makes it probable that these arise most frequently when the body louse, *P. corporis,* crosses with the head louse *P. capitis.* These intersexes have both male and female gonads and genitalia in the same individual, differently combined.

It has long been known that crosses between Gallinaceous birds give rise to males that are sterile although such males are not described as intersexes. Whether only the male hybrids survive or whether the female hybrids are sometimes turned into males is not known. Guyer has raised the question as to whether the individuals in question if ever females might be classified as males, because of the rudimentary condition of the ovary. It is well known to-day that removal of the ovary of the hen causes her to assume the male plumage (Goodale), and also it is more than suspected that tumors in the ovary or other diseases of that organ produce a like effect on the plumage. But Guyer points out that in the few cases examined by him testes were present. Riddle has described many cases in hybrid doves in which the sexual behavior of certain individuals showed them to have opposite sex tendencies from that indicated by their gonads. These he calls sex intergrades. It is well known to poultrymen that birds in poor condition sometimes behave queerly in their sex relations. It is possible that the weakened condition of these doves may have something to do with their anomalous behavior. But aside from this question it is possible to state that in one of the crosses at least, in which a sex-linked character is involved, there is good reason to believe that the normal sex chromosome relations persist. It is scarcely legitimate under these circumstances to suppose that the ordinary mechanism of sex production is changed in such cases in the sense implied or stated that males have been turned into females and females into males. Moreover it is sometimes overlooked that if such were the case very anomalous sex inheritance would follow were it possible to breed such hybrids. Unfortunately this is not possible in most of the cases at issue, since the hybrids are sterile, but in the few hybrids that have been bred no such disorder of the machinery appears and the individuals appear to be true to their sex. One must look, I think, in other directions for an explanation of the results.

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